RF 3861

Institute of Polar Studies

Report No. 52

Photogrammetric Maps of a Volcanic Eruption Area, Deception Island, Antarctica

by

Henry H. Brecher
Institute of Polar Studies and
Department of Geodetic Science

March, 1975

Prepared for

National Science Foundation
Washington, D.C.

The Ohio State University
Research Foundation
Columbus, Ohio 43212

INSTITUTE OF POLAR STUDIES
Report No. 52

PHOTOGRAMMETRIC MAPS OF A VOLCANIC ERUPTION AREA, DECEPTION ISLAND, ANTARCTICA

by

Henry H. Brecher
Institute of Polar Studies
and Department of Geodetic Sciences
The Ohio State University
Columbus, Ohio 43210

March 1975

The Ohio State University
Research Foundation
Columbus, Ohio 43212

ABSTRACT

The volcanic Deception Island, Antarctica, has erupted three times since 1967. Three maps are presented which display topographic changes of the most affected part of the island. The fourth map represents a crater in the terminus of a cirque glacier which has been recently examined. Procedures used in preparing the maps are discussed.

CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

The purpose of this publication is to present a series of three maps of a part of Deception Island which shows the progressive changes in topography of that part of the island which has been altered appreciably by volcanic eruptions in 1967, 1969 and 1970 and a larger scale map of a crater in the terminus of a cirque glacier in this area which was the subject of a recent glaciological investigation (Brecher, Nakagawa and Hughes, 1974; Hughes, Parkinson and Brecher, 1974).

The objective of this photogrammetric mapping program was to delineate the changes in morphology of the eruption-affected area at a scale large enough to be useful to current investigations in this area. It was necessary to prepare the series of three maps from existing photography and without establishing new ground control. The crater map was compiled from photography and ground control obtained specifically for this purpose. A brief description of the available photography and ground control and of the procedures used in the compilation of the maps is presented to give the user some guidance for judging their accuracy.

Hand-held photographs of the glacier crater at 1:16,000 scale were taken by the author from a helicopter in December 1972 with a NASA Lunar Module Hasselblad camera (f = 60 mm, 70 mm perforated film). These photographs are tilted at large (10^{o} to 25^{o}) angles from the vertical but are nevertheless very suitable for mapping if a plotter which can accept these tilts is used.

GROUND CONTROL

Although eight control points were established on Deception Island in 1957 by Hunting Aerosurveys Ltd. for the production of a 1:25,000 scale map of the island by the DOS from the 1956 photography (Directorate of Overseas Surveys, 1960) none of these are in locations suitable for orienting the stereoscopic models which cover the area mapped in this work. The 18 survey points established by the Naval Hydrographic Unit, Falkland Islands Dependencies Survey in 1948-49 (Hydrographic Department, Admiralty, 1949) are also not usable because they are either lost, unidentifiable or not in a suitable location. However, the local plane coordinate system established by this survey, with origin at Collins Point Lighthouse, has been adopted for the present mapping.

Consequently the following procedure was used to provide control for the compilation of the series of three maps: the coordinates of 12 sharply defined points, mostly confluences of streams, but also several buildings, were measured on a Wild A7 coordinatograph on the DOS map referred to above. Checks for paper shrinkage were made and showed that errors from this source were negligibly small. Parts of three stereo models were required to compile the 1956 map, about three fourths of the mapped area coming from one model. This model was scaled and oriented to what appeared to be the most reliably identifiable of the points picked above. A good fit on five points was obtained and the remainder were disregarded. The model was levelled

on the (inner and outer) shorelines of the island. The two adjacent models which were needed to complete coverage of the desired area were fitted to local topographic features plotted from the first (central) model and also levelled on the shorelines. It is considered that this procedure resulted in a satisfactory orientation of the three models used in compiling the 1956 map.

Several well distributed points, mostly local peaks, which were identifiable in all three sets of photography were selected to serve as control for plotting the 1968 and 1970 maps. Their planimetric positions were marked on the 1956 map and their elevations were recorded. The 1968 and 1970 stereo models were subsequently scaled, oriented and levelled on these points and on the shorelines.

Control for the 1972 crater map was established concurrently with surveys for ice motion studies for a glaciological investigation. Nine signalized points were established around the rim of the crater by intersection and trigonometric levelling using a Kern DKM 2 theodolite. Local sea level on the inner shoreline was used as the elevation datum and resection on some of the 1948-49 survey points and on prominent peaks was used for location. Scale was provided by a 100 m taped baseline. Standard errors in relative position and elevation of the control points are all less than 10 cm. The accuracy of the locally determined sea level is unknown and the geometry and redundancy of the resections is weak, so that absolute positioning may be appreciably in error.

COMPILATION

The 1956, 1968 and 1970 maps were plotted on the Wild B8 of the Department of Geodetic Science at The Ohio State University at a scale of 1:6,000 with 5 m contour interval. This is the largest scale obtainable with this instrument from the available photography. A publication scale of 1:10,000 was chosen for convenience and the reduction has been carried out photographically.

Film diapositives of the British photography were used for compilation of the 1956 map. The work was straightforward although orientation was difficult and time-consuming.

Considerable difficulties were encountered with both the 1968 and 1970 Argentine photography. Two stereoscopic models were required to cover the area to be mapped in each case. Due to an error, one of the three required 1968 photographs was not obtained. This accounts for the "missing" portion of the 1968 map. (This region does not appear to have experienced any appreciable topographic changes, incidentally). Glass diapositives were supplied. The locally available set of Metrogon distortion correction plates was used in an effort to compensate for at least part of the probably very large lens distortion. Since no better value was obtainable, the nominal focal length (152.4 mm) was used. No attempts could be made to determine a value from the photographs themselves since no precisely determined

terrain points were available. It was not possible to achieve a really "clean" relative orientation, either with or without distortion compensation plates, and all models exhibited appreciable deformation. This was manifested most obviously by the cylindrical shape of the inner shoreline, which should, of course, be a level surface. The obviously low resolution of the photographs was also disturbing.

In order to reduce the departures from a level surface at the shoreline to acceptable values (generally less than 4 m) the models for both 1968 and 1970 which covered most of the area being mapped were "broken" into two parts and each part levelled separately on the shoreline and peaks previously selected as control points. This accounts for the discontinuities in the contours. A similar "break" was also introduced in the connection between the two models for the 1970 map. An "eyeball best fit" to the shorelines and local peaks was made to level the models and in general it was possible to do this within a few meters. It will be noted that in some places the shoreline and 0 m contour do not coincide. In one case (1968) a 10 m discrepancy at a peak on the ridge line had to be accepted. In view of all of the above it is probably reasonable to assign an uncertainty of one contour interval (5 m), or slightly more, to the absolute values of the height information over most of the 1968 and 1970 maps. Planimetric accuracy is estimated to be about the same.

The glacier crater was mapped at a scale of 1:1,000 from glass diapositives using the Nistri-Bendix AP/C of the Aerial Engineering

Section of the Ohio Department of Transportation. The calibrated focal length and lens distortion (negligible) of the Hasselblad camera were determined by carrying out a field calibration. No real difficulties were encountered in compilation. There were a few regions of poor stereo vision due to shadows and lack of surface texture. Contours are dashed in these places. Note also the -3 m elevation of the lake on the crater floor. This appears to be connected to the ocean and should therefore be at sea level. Thus, it may be an indication of an error in the local determination of sea level in 1972.

ACKNOWLEDGMENTS

Diapositives of the 1956 photography were supplied by the British Directorate of Overseas Surveys. Diapositives of the 1968 and 1970 Argentine photography were made available free of charge by the Servicio de Hidrografía Naval through the good offices of the Instituto Antártico Argentino. Captain Jacques Cousteau made possible the 1972 aerial photography by putting his helicopter at our disposal for several flights. Mr. Lloyd Herd, Chief of the Aerial Engineering Section, Ohio Department of Transportation, provided time free of charge on the Department's AP/C plotter. Messrs. William Prescott, T. Neil O'Brien and George Jackson provided assistance and advice for the AP/C work. The Hasselblad camera was supplied by NASA's Johnson Manned Spacecraft Center. Dr. Sanjib K. Ghosh was project supervisor and provided valuable guidance. This project was funded by Grant No. GV-41368 from the Office of Polar Programs, National Science Foundation to the Institute of Polar Studies and The Ohio State University Research Foundation.

REFERENCES

Brecher, H., M. Nakagawa and T. Hughes, 1974. Volcanic Eruptions and the Stability of Glaciation on Deception Island, Antarctica: IAVCEI International Symposium on Volcanology, Santiago, Chile.

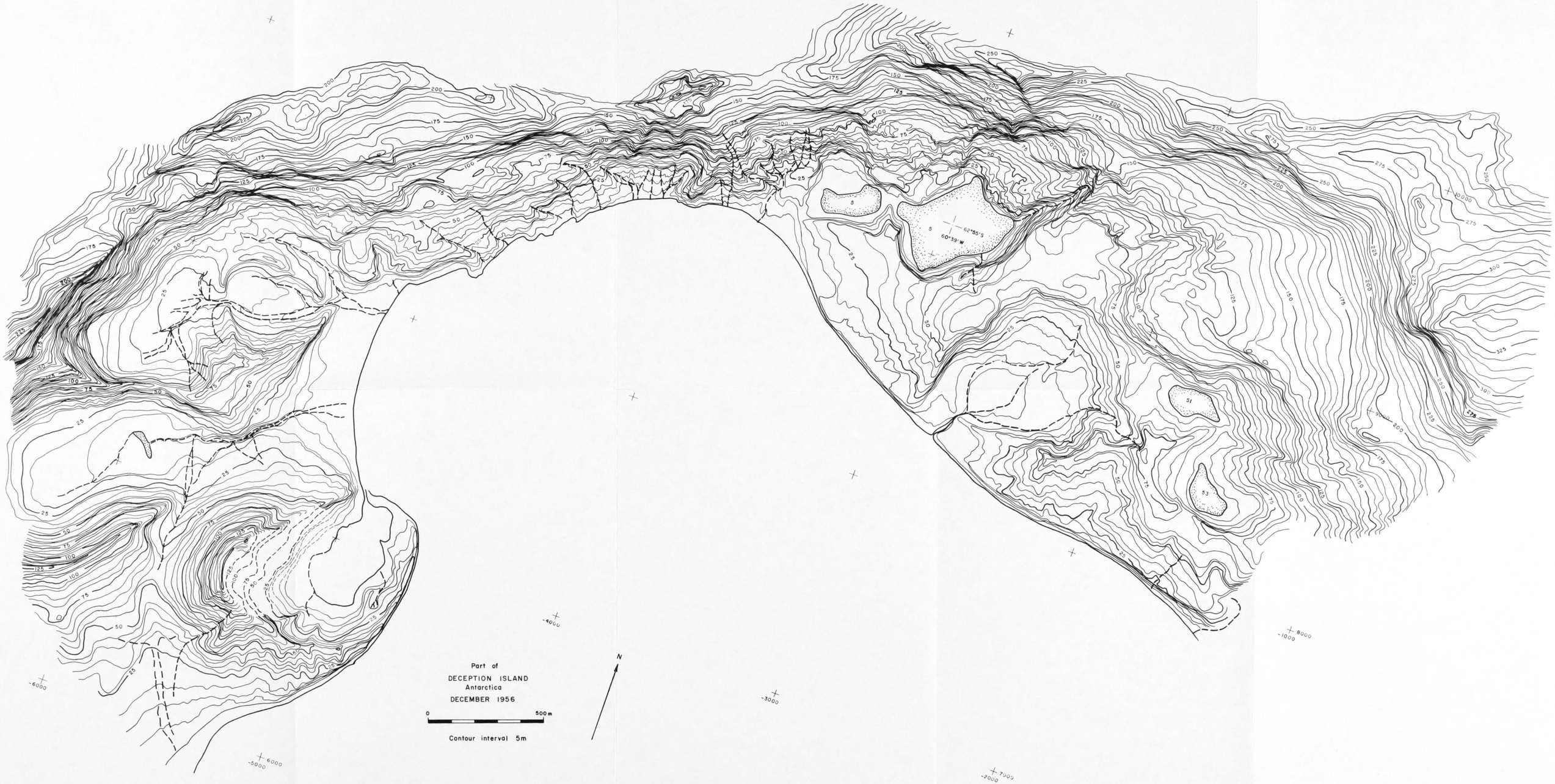
Directorate of Overseas Surveys (Great Britain), 1960. Deception Island, D.O.S. 310, scale 1:25,000 (map).

Hydrographic Department, Admiralty (Great Britain), 1949. South Shetland Islands, Deception Island, Naval Hydrographic Unit, FIDS, 1948/9, E8566 Press 31s (unpublished report).

Hughes, T., C. Parkinson and H. Brecher, 1974. Ice Dynamics Study of a Glacial Surge Induced by the August 1970 Eruption on Deception Island, Antarctica: IAVCEI International Symposium on Volcanology, Santiago, Chile.

Instituto Antártico Argentino, 1970. Deception Island Volcanic Events.

Servicio de Hidrografía Naval (Argentina), 1968. Isla Decepción, scale 1:23,150 (map).

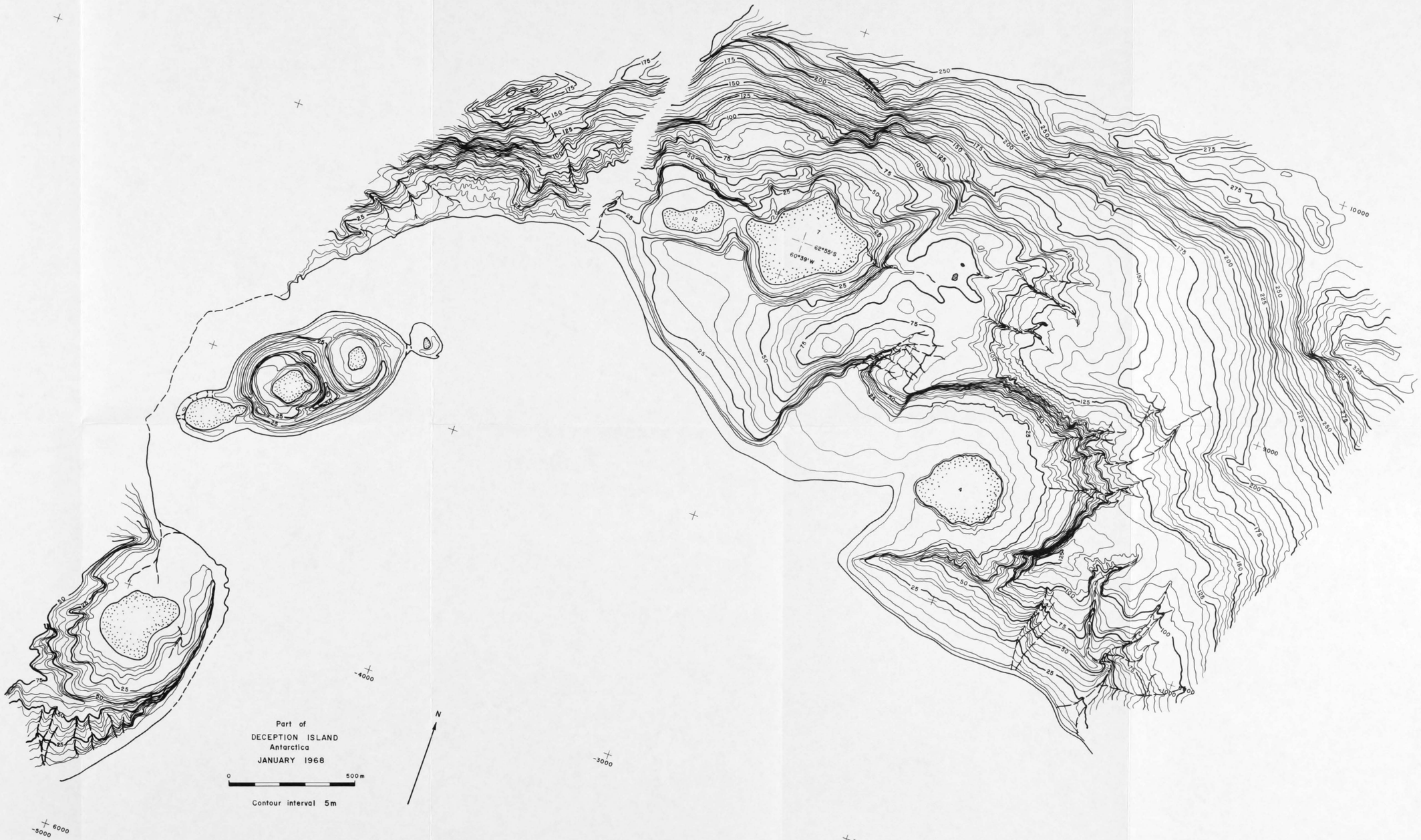


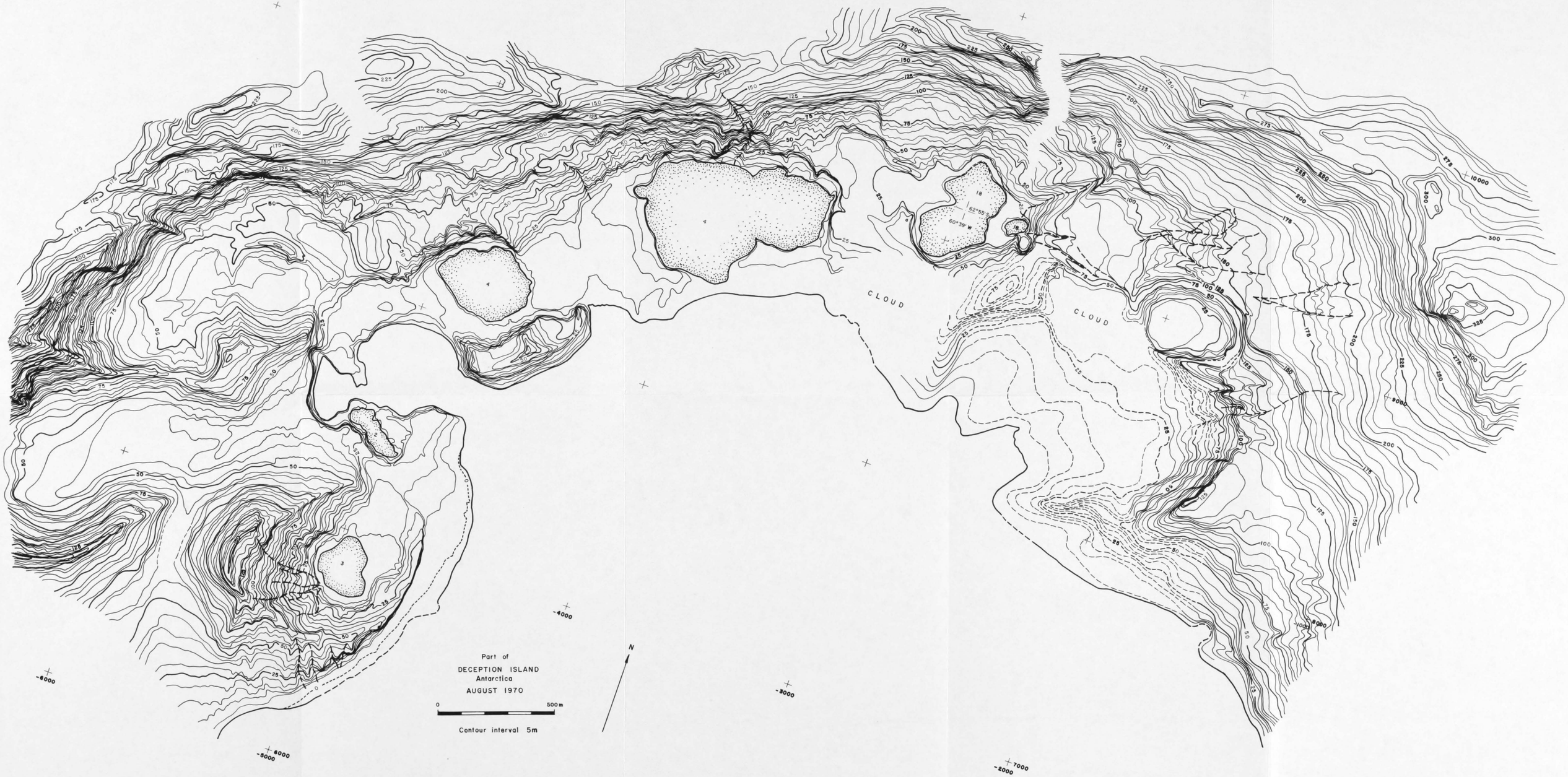
Part of
DECEPTION ISLAND
Antarctica
DECEMBER 1956

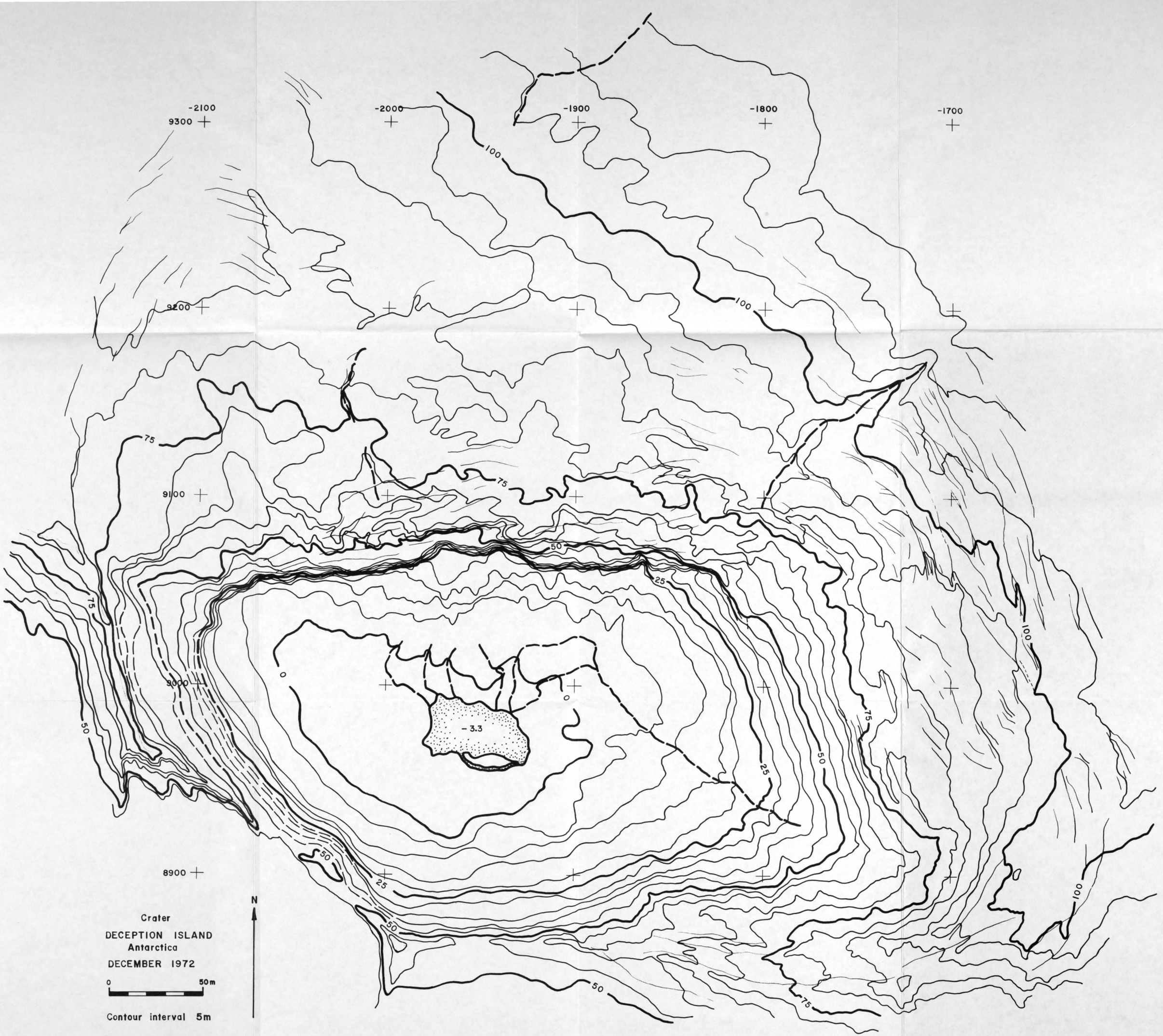
0 500 m

Contour interval 5m

N


62°55'S
60°39'W
Part of
DECEPTION ISLAND
Antarctica
JANUARY 1968
0
500m
Contour interval 5m
N


CLOUD
CLOUD
62°55'
60°39'W
Part of
DECEPTION ISLAND
Antarctica
AUGUST 1970
0
500m
Contour interval 5m
N


-2100
9300
-2000
-1900
-1800
-1700
9200
9100
9000
8900
100
75
50
25
0
-3.3
N
Crater
DECEPTION ISLAND
Antarctica
DECEMBER 1972
0
50m
Contour interval 5m